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Propagation of Trees and Shrubs by Seed

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Propagation of Trees and Shrubs by Seed*

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CAUSES AND TREATMENT OF DELAYED GERMINATION

Among the causes of natural dormancy of seed, two are particularly frequent. One is impermeability of the seed coat to water. The other is dormancy of the embryo.

Seed Coat Impermeable to Water

Three methods are commonly employed to treat seeds having an impermeable seed coat: (1) Soaking in sulphuric acid, (2) soaking in hot water, or immersing seed for a short period in boiling water, and (3) mechanical scarification. All three methods have been found in experiments at the Oklahoma Agricultural Experiment Station and elsewhere to be effective, and any one of them can be used on "hard" seed.

Sulphuric Acid Treatment.—Seed to be treated with sulphuric acid is placed in a glass or glazed clay container and concentrated acid of commercial grade poured on it. It is common to use a volume of sulphuric acid equivalent to from 3 to 10 times the volume of seed. The important point is to have every seed completely covered with acid. Dry seeds tend to float on the surface of the acid; and therefore the seed should be stirred from time to time while it is being soaked.

The period of soaking in acid depends on the species, but even within the same species there is apt to be a variation in the exact period needed to "burn off" or "thin down" the coat.

After the pre-determined period of treatment is over, the seed is removed, excess acid drained off, and the seed plunged into a large volume of cold water. The seed is then washed for 15 to 20 minutes in running water to remove all traces of acid.

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* Species discussed in this circular are those propagated from seed by plant growers in Oklahoma. The recommendations are in part the result of a research project carried on by the author at the Oklahoma Agricultural Experiment Station, and in part the result of the author's experience elsewhere. When applicable information was available from other sources, it was adopted to bring together in one place all material on the subject of interest in Oklahoma. A few references pertaining to the particular seeds, given at the end of each section, and the list of selected references of general interest, may be of help to those undertaking further study of this subject.

Since treatment of this nature is usually done immediately preceding planting, it is well to let the seed soak overnight in a large volume of fresh water after it has been washed and before it is placed in the ground. Treated seed, while soaking, will absorb a large quantity of water and will be ready to germinate immediately after being planted. When large quantities of seed are to be treated, sprinkling with sulphuric acid followed by continuous mixing of the seed (rather than soaking) is often used. This method is safer and more economical although requiring a little longer time than the use of large volume of acid.

Hot or Boiling Water Treatment.—Hot or boiling water was found also to be effective in rendering the seed coat permeable to water. One way of treatment is to heat water to between 180° and 200° F., remove it from the fire, and plunge the seed into it. Water and seed are allowed to cool together, and usually the seed is left to soak overnight or until it absorbs a large quantity of water and swells. This method is very effective on some seeds but fails on others.

Use of boiling water is more effective, although there is danger of killing or injuring the embryo if not carried out properly. The seed, placed in a bag made of cheesecloth or muslin, is plunged into boiling water and left there for a period of ½ to 2 minutes (rarely longer) while the water continues to boil. Since the boiling water treatment is always very brief it is important to remove the seed as quickly as possible. A convenient way of handling seed during this treatment is to tie a long string to the cheesecloth bag to permit quick and safe removal from the boiling water.

After the seed is removed from boiling water it is allowed to cool somewhat and is then placed in a large volume of fresh cold water to absorb moisture before being planted.

Mechanical Scarification.—Mechanical scarification is a cheap and often effective means of making the seed coat permeable to water. The whole idea of the treatment is to wear off or scratch the seed coat with some mechanical device. Where dealing with only a few seeds it may be done by scratching each individual seed with a needle point, a knife, or any such tool. When handling a large amount of seed, a "scarifier" of some type should be built to save time. The basic part of a scarifier is a large, rough surface against which the seed is thrown or blown with sufficient force to get the seed coat well scratched. A number of types of scarifiers are in use. The two described below are chosen mainly for the simplicity of their construction.

One consists of a barrel lined inside with small spikes, nails, or rough sandpaper. The barrel is mounted in a slanting position on a horizontal shaft in such a manner that it can be easily rotated either by means of a handle or through pulleys and a belt by a motor. The seed is loaded into the barrel through a small door, usually cut in the side of the barrel, and the barrel is rotated until the seeds are well scratched. This may take from a few minutes to several hours, depending on the thickness and toughness of the seed coat, the volume of seed in the barrel, as well as on the speed of rotation, the size of the barrel, and other factors.

A simple homemade device, effective with small seed (like that of black locust) in not too large a quantity is a plain tin can with a lid. The interior of the can is lined with rough sandpaper, the seed placed in it, and the can thoroughly shaken by hand. Use of such a can is very effective on seeds with relatively thin yet impermeable coats when a relatively small amount of seed is to be treated.

Dormancy of the Embryo

Of all the causes of natural delay in seed germination, dormancy of the embryo is most common. Seed with a dormant embryo must complete a process of "after-ripening" before it acquires the ability to germinate. After-ripening takes place only at the proper temperature and in the presence of abundant supplies of moisture and air (oxygen). For most of the native trees and shrubs in Oklahoma, an average temperature of 41° F. is favorable to after-ripening.

In practical handling of dormant seed, after-ripening is done by "stratification," i. e., by mixing the seed with moist sand or peat moss. The latter is preferable because it has a very large water-holding capacity and yet while moist (not wet) does not interfere with aeration of the seed.

After being thoroughly mixed with the stratification medium, the seed is placed in baskets, crates, jars, or any other convenient container and stored in a place where the temperature through a definite period of time will be maintained within the range effective in after-ripening. Standard bushel and half-bushel baskets, glass jars and tin cans are very convenient. For the sake of reducing the chances of infection or the extent of infection, it is a good policy to line the inside of a basket with clean paper before placing stratified seed into it. Stratified seed should never be packed tightly because this will interfere with good aeration.

After the mixture of seed and stratification medium is in a container, it is advisable to put on the top of the mixture an additional layer (½ inch thick) of pure peat moss or sand and to cover the container with paper. This will help in keeping the seed moist throughout the period of stratification. Properly stratified and well-covered seed kept at a low temperature should remain moist at least two or three months.

Large quantities of stratified seed can be kept in a cold room or in a cellar. When neither of these is available, it can be buried outdoors on the north side of a building. Small quantities of seed such as are commonly handled by home gardeners can be placed in small jars and kept in a refrigerator or ice box.

The length of the stratification period varies with seed of different species. The recommendation made for each species is only an average and not an exact and standard period.

Stratification periods suggested in the following text can in most cases be extended somewhat beyond the absolute requirement of the seed without any ill effect on germination. However, seed left in stratification after completing afterripening may germinate even at a low temperature, and germinated seed is always difficult to handle. It is therefore a good policy to do the planting before actual germination has taken place.

For the seed of some species, fall planting is a satisfactory substitute for stratification and saves time, labor, and space in cold storage. For these species, fall planting is effective provided the seeds remain moist and are well protected from rodents and that the temperature in the winter stays low for a sufficient length of time. In Oklahoma, however, the latter condition cannot always be depended upon, and stratification is frequently a more certain and satisfactory method of afterripening.

SEED PLANTING

The soil in which the seed is planted must be light. Fertility is less important than the physical structure of the soil.

The depth of planting commonly suggested is from 2 to 4 times the thickness of an individual seed. Very fine seed, such as birch or cottonwood or tamarix, need not be covered at all but simply pressed into the soil.

The spacing of the seed in seed beds depends on the species, the rate of growth of seedlings, the period the seedlings are to remain in seed beds and, of course, on the quality of the seed. No general rule can be given.

The seed bed should be kept continuously moist; yet one should avoid over-flooding. Seed requires air; and presence of an excessive amount of water reduces the amount of air available to the seed.

As an additional precaution for maintaining moisture in the seed bed, it is a common practice to cover the latter with burlap, paper, green branches, or clean straw. Besides conserving moisture, such covers protect the seed from being washed off or blown away; and they also protect it to some extent from being destroyed by rodents. Such protection is especially needed by fall plantings. When the seedlings begin to appear above the ground, the cover should be either completely removed or raised to permit free, unobstructed growth.

FRUIT TREES

Apple. *Malus* spp. (Plate I)

The seed of apple is used primarily for the production of rootstocks, since apple varieties do not come true to seed.

The seed of apples is dormant and requires stratification at 34° to 40° F. for a period of 2 to 2½ months for the completion of after-ripening.

From the time of its extraction from the fruit, the seed should be kept continuously moist. Excessively prolonged drying results in the loss of seed vitality.

Selected References:

Bakke, A. L., Richey, H. W., and Reeves, Kenneth. Germination and storage of apple seeds. Iowa Agr. Exp. Sta. Res. Bul. 97. 1926.

Harrington, G. T. and Hite, B. C. After-ripening and germination of apple seeds. Jour. Agr. Res 23: 153-161. 1923.

Haut, I. C. Physiological studies on after-ripening and germination of fruit-tree seeds. Md. Agr. Exp. Sta. Bul. 420. 1938.

Tukey, H. B. Studies of fruit seed storage and germination. N. Y. State Agr. Exp. Sta. Bul. 509. 1924.

Pear. *Pyrus* spp. (Plate I)

Pear seed, as that of the apple, is used primarily for the production of rootstocks.

Since pear seed should not be allowed to dry, it must be kept at a rather high humidity. The best stratification temperature for pear seed is 37° F. At that temperature the seed after-ripens in stratification in approximately 60 days.

Selected References:

Haut, I. C. Physiological studies on after-ripening and germination of apple seeds. Jour. Agr. Res. 23: 153-161. 1923.

Veh, Robert von. Eine neue Methode der Anzucht vor Samlingen, unabhanging von Ruheperioden und Jahreszeit (bei Apfeln, Birnen, Quitten, Pflaumen, Kirchen) Zuchter 8: 145-151. 1936.

CHERRY. *Prunus* spp. (Plate I)

The seeds of all common species of cherries have a period of dormancy. Various species and varieties of cherry differ somewhat in their stratification requirements, some after-ripening in a course of four weeks, others requiring as long as 14 or more weeks under the same conditions. The after-ripened seeds germinate and the seedlings grow freely at a temperature close to freezing, so a long period of stratification cannot be recommended.

The following is probably the safest schedule:

Species	Period (days)	Temperature (F.)
P. mahaleb	88	37°
P. ovium (Mazzard)	100-125	37°
P. serotina (Black)	30-60	32°-50°

While in stratification, cherry seed must be under continuous observation, particularly during the last part of the recommended stratification period. If the completion of after-ripening occurs too far in advance of the time of planting (as evidenced by cracking of the seed coat), the temperature of stratification should be lowered to 31° to 32° F. for the rest of the stratification period.

Selected References:

Haut, I. C. The influence of drying on the after-ripening and germination of fruit tree seeds. Amer. Soc. Hort. Sci. Proc. 29: 371-374. (1932) 1933.

Haut, I. C. Physiological studies on after-ripening and germination of fruit-tree seeds. Md. Agr. Exp. Sta. Bul. 420. 1938.

N. Y. State Conserv. Dept. Treatment of black cherry seed to secure first-year germination. N. Y. State Conserv. Dept. Notes on forest investigations No. 5, December, 1937 (not published).

Paton, R. R. Preplanting treatment of black cherry seed. Jour. Forestry 34: 730. 1936.

Tukey, H. B. Development of cherry and peach fruits as affected by destruction of the embryo. Bot. Gaz. 98: 1-24. 1926.

PLUM. *Prunus* spp. (Plate I)

Plum seed requires stratification, the exact period varying with the species as well as with individual lots. The common wild plum of Oklahoma *(Prunus angustifolia)* is usually well after-ripened after stratification of 60 to 90 days at 34° to 40° F.

Plum seed germinates abundantly and freely at a low temperature once the after-ripening is completed. Therefore the same precautions and periodic observations of stratified seed as for cherry are recommended.

Selected References:

Giersbach, J. and W. Crocker. Germination and storage of wild plum seeds. Boyce Thompson Inst. Contrib. 4: 39-51. 1932.

PEACH. *Prunus persica* (Plate I)

At the time of ripening, as much as 50 percent of the seed may be dormant. In commercial nursery practice, peach stones are commonly planted in the fall of the year. They usually germinate freely the following spring, because fall planting provides the conditions for after-ripening. However, one can expect somewhat better results if the seeds are stratified over winter under controlled conditions and planted in the spring. The most favorable stratification temperature for peach is between 32° and 45° F. At this temperature the seed after-ripens in approximately 75 to 100 days.

Selected References:

Crocker, W. and Barton, L. V. After-ripening, germination, and storage of certain Rosaceous seeds. Boyce Thompson Inst. Contrib. 3: 385-404. 1931.

Haut, I. C. Physiological studies on after-ripening and germination of fruit-tree seeds. Md. Agr. Exp. Sta. Bul. 420. 1938.

Gardner, F. E. and Marth, P. C. Germination and seedling vigor of peach varieties for understocks. Amer. Soc. Hort. Sci. Proc. 35: 409-414. (1937) 1938.

Flemion, F. A rapid method for determining the germinative power of peach seeds. Boyce Thompson . Inst. Contrib. 8: 289-293. 1936.

Tukey, H. B. and Barrett, M. S. Approximate germination test for non-after-ripened peach seeds. Plant Physiol. 11: 629-633. 1936.

APRICOT. *Prunus armeniaca.*

Apricot pits are handled somewhat like those of peach. Fall planting of recently collected seeds or spring planting of seeds stratified at low temperature over winter should prove successful.

PERSIMMON. *Diospyros virginiana.* (Plate I)

Propagation of persimmon is considered difficult and germination of its seed uncertain. The seed is dormant when ripe, the cause of the dormancy lying in the embryo. Stratification at low temperature for a period of 40 to 20 days, or fall planting of unstratified seed, have been reported effective in breaking dormancy and forcing germination.

Selected References:

Fletcher, W. F. The native persimmon. U. S. D. A. Farmers' Bul. 685. 1915. Revised 1935.

SMALL FRUIT

BLACKBERRIES. *Rubus* spp.

Blackberry seed, due to the dormancy of its embryo, requires stratification at 33° to 35° F. before being planted. The stratification requirement varies considerably, sometimes as long as 5 to 6 months being necessary. The average is approximately three months. September is suggested as the best time for planting.

Although the seed coat is not impermeable to water, some propagators report improvement in after-ripening and germination if the seed is treated with concentrated sulphuric acid. The suggested periods of acid treatment range from 2 to 4 hours. Commercial varieties of blackberries are commonly propagated by root cuttings.

Selected References:

Odland, T. E. and Stene, A. E. Inheritance in blackberries. Amer. Soc. Hort. Sci. Proc. 33: 423-426. (1935) 1936.

GRAPES. *Vitis* spp.

Grape seed requires stratification at 37° F., varying in length from 90 to 140 days. Commercially, stratification usually lasts throughout the winter. In places where the climatic conditions during the winter permit it, fall planting is used instead of stratification. Dry storage of seed for two or three months prior to stratification or fall planting will improve germination markedly.

Because of the great variation of grape seedlings, seed alone cannot be relied upon to produce a vineyard of the desired variety. Commercial varieties of grape are propagated by cuttings and grafting and, less often, by budding and layering.

Selected References:

Adams, J. The germination of the seeds of some plants with fleshy fruits. Amer. Jour. Bot. 14: 415-428. 1927.

Chauveaud, G. Moyen d'assurer et de rendre tres pative la germination des vignes. Compt. Rend. 118: 211-212. 1894.

Flemion, F. After-ripening at 5° C. favors germination of grape seeds. Boyce Thompson Inst. Contrib. 9: 7-15. 1937.

NUT TREES

HICKORIES. *Carya* spp. (Plate II)

The seeds of most hickories are dormant, requiring stratification for various periods of time, depending on the species and, to some extent, on the origin of the seed. When hickory nuts are collected with the husk still on, it is desirable, though not necessary, to remove the husk prior to stratification. The husk, under moist conditions, rots easily and if left in contact with the nut for a considerable period of time may contribute to infection and injury to the nut. The approximate stratification requirement of nuts of the most common Oklahoma hickories is 3 months at 33° to 50° F. Fall planting of hickory nuts might be, and often is, used very successfully, provided that the nuts are well protected against rodents and severe freeze. Exposure of hickory nuts to freezing and thawing, contray to a rather common popular belief, is said to be harmful and certainly not essential for after-ripening.

The PECAN *(C. illionesis)* (Plate II) differs from other hickory nuts in its characteristics and requirements. It does not fall into dormancy but can germinate at any time when conditions are favorable. Despite this difference, pecan seed is commonly stratified or kept in cold storage at high humidity through the winter and planted in the spring of the year. Such a type of winter storage prevents the nut from getting rancid and from losing its viability and, at the same time, excludes the possibility of germination. If planted during the fall and winter, the pecan, not being dormant, will germinate whenever the weather turns favorable.

Selected References:

Bailey, J. E. and Woodroof, J. G. Propagation of pecans. Ga. Agr. Exp. Sta. Bul. 172. 1932.

Barton, L. V. Seedling production in **Carya ovata** (Mill.) K. Koch., **Juglans cinerea** L. and **Juglans nigra** L. Boyce Thompson Inst. Contrib. 8: 1-5. 1936.

Delavan, C. C. The relation of the storage of the seeds of some of the oaks and hickories to their germination. Mich. Acad. Sci. Ann. Rpt. 17: 161-163. 1916.

McHatton, T. H. and Woodroof, J. G. Some factors influencing pecan germination. Amer. Soc. Hort. Sci. Proc. 24: 125-129. (1927) 1928.

Reed, C. A. Nut-tree propagation. U. S. D. A. Farmers' Bul. 1501. 1926.

Traub, H. P. and Muller, H. J. X-ray dosage in relation to germination of pecan nuts. Bot. Gaz. 95: 702-706. 1934.

BLACK WALNUT. *Juglans nigra.* (Plate II)

Black walnut when ripened and shed from the tree is dormant. The seed coat, though extremely hard, permits the kernel to absorb water rather freely. By the time the kernel after-ripens and is ready to resume growth, the hard seed coat cracks along the edges and thus presents no obstacle to the growing embryo. Black walnut after-ripens in stratification at 33° to 50° in two or three months. Many propagators prefer fall planting, but in Oklahoma the winter temperature may not stay low for a sufficient length of time. Instances are recorded when many black walnuts, planted in the nursery in the fall, failed to germinate during the first spring but produced seedlings only after another winter in the ground.

Selected References:

Anonymous. Germination of walnuts: methods of procuring. Soc. Cent. Forest. de Belg. Bul. 34: 121-123. 1931

Anonymous. Means of hastening germination of **Juglans nigra** seed. Soc. Cent. Forest. de Bel. Bul. 10: 46-48. 1903.

Barton, L. V. Seedling production in **Carya ovata** (Mill.) K. Koch. **Juglans cinera** L., and **Juglans nigra** L. Boyce Thompson Inst. Contrib. 8: 1-5. 1936.

Schwartz. Over winter storing of **Juglans nigra** nuts. Wien Allg. Forst. u. Jagd. Ztg. 50: 281. 1932.

Walkenhorst. Experiments with Juglans seedlings. Deutsche Forstwirt. 15: 674-675. 1933.

ORNAMENTAL AND SHADE TREES

PINES. *Pinus* spp. (Plate II)

Pine seed in general is somewhat variable in its ability to germinate immediately after reaching maturity. Some are unable to do so without pre-treatment; others germinate rather freely. In any case, stratification will improve the uniformity and rate of germination as well as the growth and vigor of seedlings. For this reason, stratification is recommended for all species of pine.

The following is the schedule of stratification of pines grown in Oklahoma:

	Stratification period at 33° to 40° F. (Days)
Shortleaf	30-60
Western yellow	30-60
Pinon	20-30
Austrian	30-60
Scotch	60-90
Japanese red	60

Pine seed is collected while it is still enclosed within a cone. The proper time of gathering cones is when they become able to float in water or in 20 weight lubricating oil. This occurs approximately two weeks before the cones begin to crack open. Freshly collected cones should be spread in a thin layer and allowed to dry. In commercial practice, artificial heat is often applied; but this must be done according to a definite schedule and under definite ranges of temperatures. It is much safer for a person lacking proper equipment to let the cones dry without applying artificial heat. When the cones are drying, their scales open and the seed can easily be shaken loose.

Selected References:

Barton, L. V. Hastening the germination of some coniferous seeds. Amer. Jour. Bot. 17: 88-115. 1930.

Barton, L. V. Storage of some coniferous seeds. Boyce Thompson Inst. Contrib. 7: 379-404. 1935.

Mirov, N. T. A note on germination methods for coniferous species. Jour. Forestry 34: 719-723. 1936.

Show, S. B. Methods of hastening germination. Jour. Forestry 15: 1003-1006. 1917.

Toumey, J. W. and Korstian, C. F. Seeding and planting in the practice of forestry. John Wiley & Sons. N. Y.

ARBORVITAE, BIOTA. *Thuja orientalis.* (Plate II)

The seed of this species requires no pre-treatment for germination. After the fruit is collected and the seed removed, the latter is spread in a thin layer to dry. When dry, it is placed in sacks or any other type of container and stored till spring, preferaby in a cool place.

The seed can be planted in the spring either directly from storage (dry) or after a day of soaking in cold water. Stratification is not necessary and seldom, if ever, is used commercially; yet the tremendous improvement in germination caused by a short period of stratification unquestionably justifies a little extra work connected with stratification.

RED CEDAR. *Juniperus virginiana.* (Plate III)

Dormancy of the embryo is the cause of delayed germination of seed of the eastern red cedar. This condition is corrected by stratifying the seed at low temperature (33° to 40° F.) for 3 or 3½ months. Seed of red cedar germinates best at temperatures of 55° to 60° F. and for that reason it is preferable to plant it early before the arrival of extremely hot days. The following procedure and schedule are suggested for handling red cedar seeds in Oklahoma:

Soak the berries in water for two or three days until the pulp gets soft and the berries are easily squashed with the fingers. Remove pulp by rubbing berries on a hard, rough surface (cement floor) with a brick or with a screen-covered block. The pulp may then be washed off. Seed which floats with the pulp is usually poor in quality and may be discarded.

Spread the good seed in a thin layer and let it dry for several days. Do not use artificial heat. All the foregoing steps must preferably be completed not later than the middle of December.

In December, stratify the seed and place it at a temperature of 32° to 35° F. When seed has after-ripened (February or March) it is ready to be planted. Completion of after-ripening is marked by the splitting of the seed coats.

Sow seed in a light soil at a depth of ¼ to ⅜ inch. Keep the seed bed continuously moist, but not too wet. Very little moisture is needed for germination.

If a low-temperature storage facilities are not available, sow seeds in December or January. Some recommend this practice in preference to artificial cold storage.

Although abundant crops of seed are produced occasionally by the common red cedar of Oklahoma, the quality of the seed is often very low. Sometimes more than 80 percent of seeds are empty and entirely worthless. It will always pay, therefore, to cut open about 100 seeds and examine their quality before starting a large scale seed collection from any tree.

ROCKY MOUNTAIN RED CEDAR. *Juniperus scopulorum.*
(Plate III)

Although the seed of this species is very much like that of the common red cedar in its structure, its behavior is markedly different. Dormancy of the embryo is known to be the cause of delayed germination of this seed. Impermeability of the seed coat may also be involved. The seed requires stratification, first at low temperature, then at high and finally at low temperature again. Stratification at 33° to 40° alone, no matter how long, does not break the dormancy of the seed.

In practical production, the seeds may be planted in winter and kept in the seedbed until the second spring, at which time they germinate freely. When seedbed space is scarce, and too valuable to be occupied by one crop of seed for more than a year, seeds may be placed between two layers of light soil in a flat or a basket and kept buried in the ground for the first year. During the second winter the seeds are removed from the containers and sown in a seedbed in ordinary manner.

Only a portion of seedlings (often a very small portion) of ornamental varieties of *J. scopulorum* will look like their parent trees, particularly in respect to the color of the foliage. Another drawback in the production of *J. scopulorum* by seed is the extremely slow growth of young seedlings.

Most of the ornamental varieties of *J. scopulorum* are propagated by grafting rather than by seed.

Selected References:

Afanasiev, M. and Cress, M. Producing seedlings of Eastern red cedar (**Juniperus virginiana**). Okla. Agr. Exp. Sta. Bul. 256. 1942.

Afanasiev, M. and Cress, M. Changes within the seeds of **Juniperus scopulorum** during the process of after-ripening and germination. Jour. Forestry. (In press.)

Jelley, M. E. Eastern red cedar. Jour. Forestry. 35: 865-867. 1937.

Pack, D. A. After-ripening and germination of **Juniperus** seeds. Bot. Gaz. 71: 32-60. 1921.

Pack, D. A. Chemistry of after-ripening, germination, and seedling development of Juniper seeds. Bot. Gaz. 72: 139-150. 1921.

COTTONWOOD, *Populus* spp.; and WILLOWS, *Salix* spp.

Seeds of cottonwood and willows are never dormant and are usually planted as soon as collected. The normal longevity of seeds of both plants is very short, probably not exceeding three or four weeks, so they should be planted as soon as possible. When planting must be delayed, the seed should be dried for a few days and then stored at approximately 40° F. Cuttings of both species root rather easily, and this method of propagation is often used in preference to propagation by seed.

Selected References:

Faust, M. E. Germination of **Populus grandidentata** and **P. tremuloides** with particular reference to oxygen consumption. Bot. Gaz. 97: 808-821. 1936.

Moss, E. H. Longevity of seed and establishment of seedlings in species of populus. Bot. Gaz. 99: 529-542. 1938.

Nilsson, N. H. The physiology of willow seed. Bot. Notiser. 1928: 255-264. 1928.

BIRCH. *Betula* spp.

Birch seeds are commonly planted without being treated. At least a short period of stratification, however, results in a more uniform and rapid germination of all seeds and in production of more vigorous and healthy seedlings. Stratification also reduces the temperature at which germination takes place, thus permitting earlier germination and somewhat lengthening the growing season. Stratification at 41° F. does not need to be longer than two or three weeks.

Selected References:

Anonymous. Collection and storage of birch seed. Soc. Centrale Forest. Bel. Bul. 37: 382-383. 1930.

Fabricius, L. Korstliche Versuche V: Die Einwirkling von waldbrandasche auf Saem Keimung und erste Pflanzenentwicklung. Forstwiss. Centbl. 51 (8): 269-276. 1929.

Joseph, H. C. Germination and viability of birch seeds. Bot. Gaz. 87: 127-151. 1929.

Patterson, C. F. and Bunce, A. C. Rapid methods of determining the percentages of fertility and sterility in seeds of the genus Betula. Sci. Agr. 11: 704-708. 1931.

Weiss, Freeman. Seed germination in the gray birch, **Betula populifolia.** Amer. Jour. Bot. 13: 737-742. 1926.

OAKS. *Quercus* spp. (Plate III)

Because of the close similarity in the character and behavior of acorns belonging to the same botanical group, suggestions concerning handling of acorns will cover the entire group rather than individual species.

Botanically, oaks found in Oklahoma belong to two distinct groups: (1) white oak and (2) black oak. The white oak group includes white oak, bur oak, and post oak. To the black oak group belong black oak, red oak, southern red oak, blackjack oak, scarlet oak, and pin oak.

White Oak Group

The acorns of white oaks are often said to have no period of dormancy, yet in many instances no germination can be secured immediately after their collection. Stratification will increase total germination and make it more uniform, and will also add to the vigor of young seedlings.

Acorns of the white oak group should be stratified as soon as collected, and stored at a temperature just above freezing. The acorns of this group should not be allowed to dry, being much more susceptible to injury from lack of moisture than are the acorns of black oaks.

Planting white oak acorns in the fall of the year has proved to be as good as spring planting of stratified seed, and this eliminates some extra labor. But fall plantings should be adequately protected from rodents, which can destroy overnight a large quantity of seed.

Black Oak Group

Acorns of the black oak group are dormant when they ripen and have to pass through a period of stratification before they become able to germinate.

Black oak acorns can withstand dry storage considerably longer than those of white oaks, but should be kept at a low temperature. Extending the period of stratification beyond the need for after-ripening may result in an abundant and rapid germination.

The following are stratification requirements (at 33° to 40° F.) of acorns of various oaks in this group:

	Stratification Period (Weeks)
Red oak	12
Southern red oak	3-4
Black oak	4-10
Pin oak	4-6
Scarlet oak	10-12

In order to avoid dificulties connected with germination in storage, many growers prefer to plant the acorns in the fall, even if the final germination is likely to be somewhat lower than in the case of stratified seed. While in the ground, the acorns should be continuously protected from rodents.

Selected References:

Delavan, C. C. The relation of the storage of the seeds of some of the oaks and hickories to their germination. Mich. Acad. Sci. Ann. Rpt. 17: 161-163. 1916.

Deuber, C. G. Chemical treatments to shorten the rest period of red and black oak acorns. Jour. Forestry. 30: 674-679. 1932.

Harshberger, J. W. A new method of germinating acorns for forest planting. Amer. Forestry 22: 275-687. 1916.

Korstian, C. F. Acorn storage in southern U. S. A. Jour. Forestry. 28: 858-863. 1930.

Korstian, C. F. Factors controlling germination and early survival in oaks. Yale Univ. Sch. Forestry. Bul. 19, 115 p. 1927.

Toumey, J. W. and Korstian, C. F. Seeding and planting in the practice of forestry. John Wiley & Sons, Inc., N. Y. City.

ELMS. *Ulmus* spp. (Plate III)

The behavior of elm seeds varies with the species. American *(U. americana),* Asiatic—commonly known as Chinese—*(U. pumila),* and winged (U. alata) elms germinate rather freely without any treatment, shortly after the seed is shed from the trees. The seeds are usually planted as soon as they become available in the spring of the year. Stratification of American elm seed for two or three weeks improves the rate of germination and growth of young seedlings.

Seeds of the true Chinese *(U. parvifolia)* and slippery *(U. fulva)* elms are dormant and require stratification. The seed of the *parvifolia* elm ripens in the fall of the year, so there is time enough for the seed to after-ripen in stratification before planting time the following spring. The average stratification requirement of the seed is four weeks.

Dormancy of the seed of slippery elm can be broken by stratification for approximately six weeks. Since the seed ripens in the spring, it should be stratified immediately after being collected so that it will be ready for planting not later than May.

Despite the delicate nature of elm seeds they can be kept viable for at least as long as one year if stored in a tightly closed container at a relatively low temperature (35° to 40° F.)

Selected References:

Barton, L. Storage of elm seeds. Boyce Thompson Inst. Contrib. 10: 221-233. 1939.

George, E. J. Storage and dewinging of American elm seed. Jour. Forestry 35: 769-772. 1937.

Rudolf, P. O. Delayed germination in American elm. Jour. Forestry 35: 876-877. 1937.

Steinbaur, C. E. and Steinbauer, G. P. Effects of temperature and desiccation during storage on germination of seeds of the American elm (**Ulmus americana** L.). Amer. Soc. Hort. Sci. Proc. 28: 441-443. 1932.

HACKBERRY. *Celtis* spp. (Plate IV)

The dormancy of hackberries found in Oklahoma *(C. occidentalis* and *C. laevigata)* is due to the dormancy of the embryo and probably, at least to some extent, to the characteristics of the seed coat. Stratification at 41° F., according to the experience at the Oklahoma Agricultural Experiment Station, brings about after-ripening, but rather slowly and inefficiently. If stratification alone is used, the seed must be stratified as soon as it becomes available in the fall.

Treatment of dry seed with concentrated sulphuric acid for two one-hour periods, each followed by thorough washing in cold water, is said to be the most effective way to force germination of hackberry.

Selected References:

Lake States For. Exp. Sta. Seed treatment for shelterbelt species. For. Res. Digest 6-7. Aug., 1935.

MULBERRY. *Morus* spp. (Plate IV)

Mulberry fruit should be fermented for 24 to 48 hours and de-pulped immediately after collection. The seed may be sown soon after it is cleaned. A better method is to sow it either during the following fall or spring, keeping it up to that time at a relatively low temperature. For fall planting, the

seed should be soaked in cold water for four to five days just before it is placed in the ground. For spring planting, eight to ten weeks of stratification at 33° to 50° F. (preferably 33° F.) will help considerably in increasing the number of germinating seeds and improving the vigor of the seedlings.

Selected References:

Fisher, P. L., Briggs, A. H., Elkins, W. A., and Roe, E. I. Propagation of game food and cover plants of the Lake States. Lake States For. Exp. Sta. 1935. (mimeographed.)

OSAGE ORANGE, BOIS D'ARC. *Maclura pomifera.* (Plate IV)

Osage orange seed has no period of dormancy and does not necessarily require any treatment prior to planting. However, its germination can be improved and speeded up by stratification at a low temperature for two or three weeks. Another simple method of improving germination, though not as effective as stratification, is to soak the seed for five to seven days in cold water, changing the water every day.

Extraction and cleaning of seeds is the most difficult part of propagation of osage orange.

As soon as gathered, the fruit should be broken into pieces, using a wooden club or a brick, and buried in the ground about one foot deep. By the following spring the fruit decays, turning into a soft, sticky mass of pulp. A wire screen and a liberal amount of water permit the separation of seed from the pulp.

Storage in the ground also improves germination. If the seed is relatively dry when dug out from the ground, it should be soaked in cold water for a day or two before being planted.

Selected References:

Fisher, P. L., Briggs, A. H., Elkins, W. A., and Roe, E. I. Propagation of game food and cover plants of the Lake States. Lake States For. Exp. Sta. 1935. (mimeographed.)

SWEET GUM. *Liquidambar styrasiflua.*

The seed of sweet gum germinates occasionally without any pre-treatment. In commercial propagation the seed is commonly stratified throughout the winter and planted in the spring. Some seeds fail to germinate during the first year and the appearance of seedlings during the second spring is not uncommon.

MAGNOLIA. *Magnolia grandiflora.* (Plate IV)

Magnolia seed must be stratified before being planted. After-ripening of the seed is normally completed in stratifica-

(Text continued on page 31.)

Plate I

Apple
Plum
Pear
Peach
Cherry
Persimmon

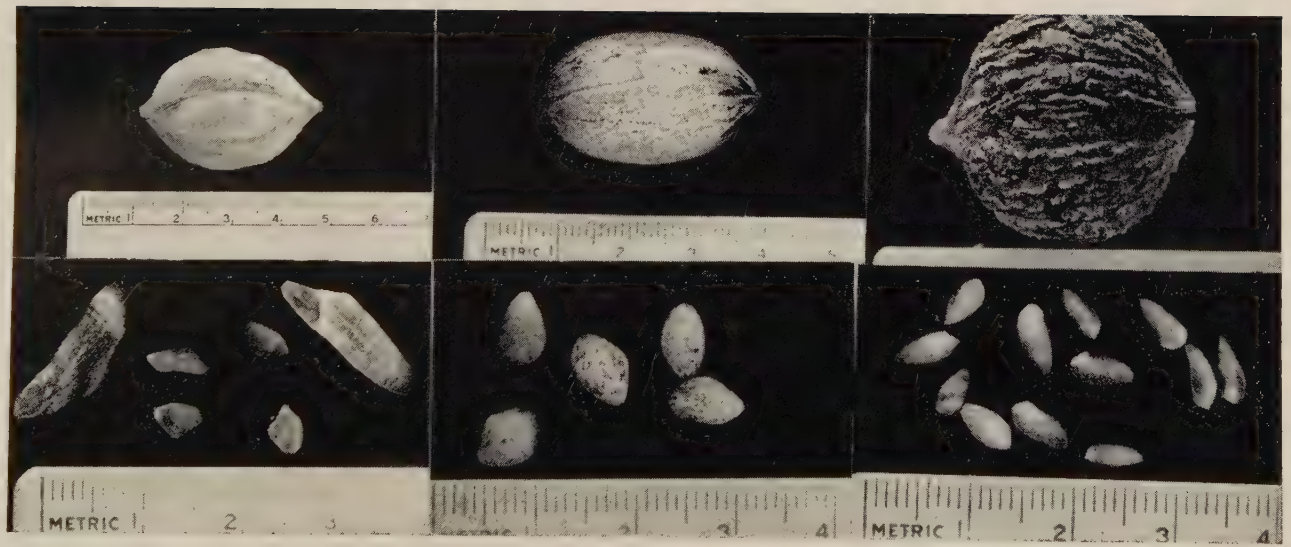

Plate II

Hickory
Shortleaf pine

Pecan
Western yellow pine

Black walnut
Arborvitae

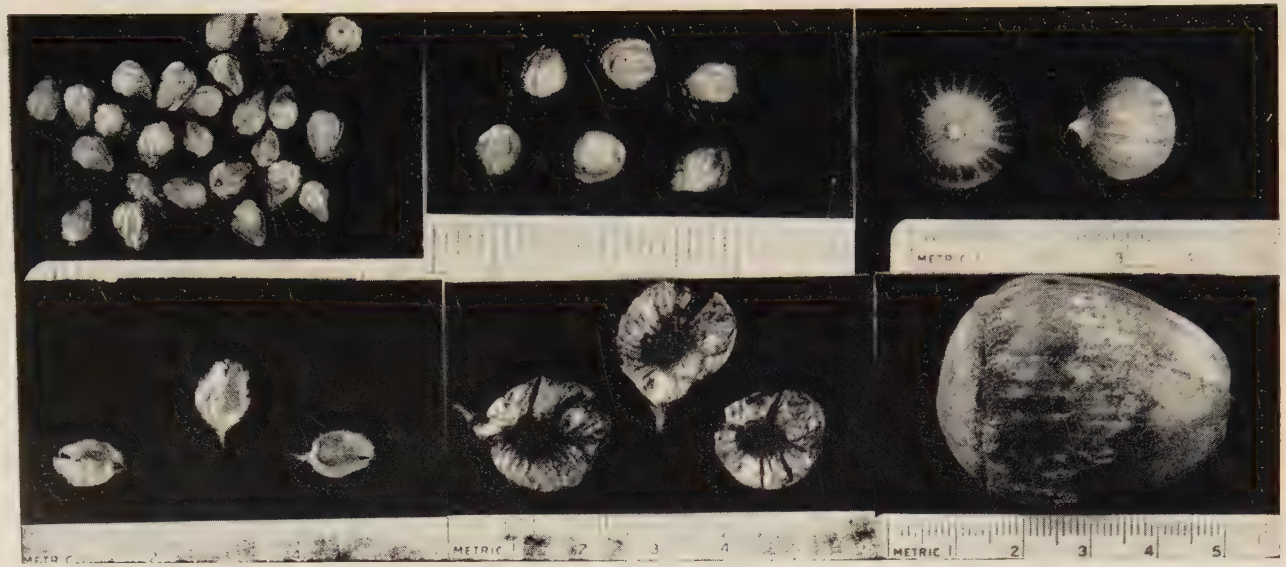

Plate III

Red cedar
American elm

Scoupulorum juniper
Chinese elm

Pin oak
Bur oak

Plate IV

Hackberry
Magnolia

Mulberry
Sycamore

Osage orange
Redbud

Plate V

Black locust
Wafer ash

Honey locust
Tree of Heaven

Kentucky coffee tree
Deciduous holly

Plate VI

American holly
Soapberry

Silver maple
Chittamwood

Box elder
White ash

Plate VII

Green ash
Barberry

Catalpa
Bird-of-paradise

Russian olive
Cherry laurel

Plate VIII

Desert willow
Privet
Euonymus
Flowering quince
Nandina
Rose

tion at about 40° F. in eight or ten weeks. The readiness of the seed to germinate is marked by the splitting of the inner seed coat. The outer seed coat (red fleshy pulp) must be removed before the seed is stratified. This can be done very easily after soaking the seed in water for one or two days. Separation of good, well-filled seeds from the empty ones can be easily accomplished by placing them in water. The good seeds (without the red pulp) sink, while the empty seeds and the pulp float.

Because of the relatively slow growth of young seedlings, they are often started indoors in flats or pots in mid-winter and lined out in the nursery later in the spring. Addition of organic material to the seedbed and partial protection against direct sunlight are favorable to the growth of small seedlings.

Selected References:

Afanasiev, M. A physiological study of dormancy in seed of **Magnolia acuminata.** N. Y. (Cornell) Agr. Exp. Sta. Mem. 208. 1937.

Evans, C. R. Germination behavior of **Magnolia grandiflora.** Bot. Gaz. 94: 729-754. 1933.

SYCAMORE. *Platanus occidentalis.* (Plate IV)

The seed of sycamore is usually planted in the fall of the year or stratified throughout the winter and planted in the spring. Exposing the seed to freezing is said to be helpful in forcing it to germinate.

HAWTHORNS. *Crataegus* spp.

The seeds of all hawthorns are dormant and need stratification. Requirements vary with individual species. Seed coats seem to have a slight inhibitive effect on the rate of afterripening. When both seed coats are removed, growth of the embryo may be expected within a month or so. However, the seedlings produced in such a short period of time are dwarfed, extremely slow growing, and probably will never develop into normal, healthy plants unless the seed is held for some time at a low temperature.

Stratification of the seed still enclosed within the seed coats lengthens the stratification period but results in the production of normal and sound seedlings. The average requirement is approximately 100 days at a temperature of 41° to 43° F.

Selected References:

Davis, E. and Rose, R. C. The effect of external conditions upon the after-ripening of the seeds of **Crataegus mollis.** Bot. Gaz. 54: 49-62. 1912.

Flemion, F. Breaking the dormancy of seeds of Crataegus species. Boyce Thompson Inst. Contrib. 9: 409-423. 1938.

REDBUD. *Cercis canadensis.* (Plate IV)

After collection, the seed of redbud should be removed from the pods, spread in a thin layer, and allowed to dry for several days. Neither artificial heat nor direct sunlight should be employed in drying seed. Dried seed can be stored in any kind of container, but should be kept in a cool place.

If the seed appears to be badly infested with insects, which is often the case with the redbud, the insects must be destroyed before the seed is placed in storage. The most effective way to do that is to place seed in a container with a small amount of carbon bisulphide in a tumbler set on the top of the seed. The container must then be closed tightly and left to stand for 24 hours. (CAUTION: Carbon bisulphide fumes are inflammable, and are poisonous if inhaled.)

Treatment of seed should begin about two months in advance of planting time. The dried seed is soaked in full strength commercial sulphuric acid for about 20 minutes. Some lots may require a little shorter or a little longer time. While the seed is in the acid, it should be stirred from time to time so as to receive the treatment uniformly on all sides. After removal from the acid, wash the seed well for 10 to 15 minutes in running water, and then soak in fresh water. During several hours of soaking, the seed absorbs a large quantity of water and swells to several times its original volume. It is then rinsed again in fresh water, mixed with three to four times its volume of moist peat moss or sand, and set at 35° to 45° F. for 50 to 60 days. After this period the seed is ready to germinate.

Selected References:

Afanasiev, M. Germination of redbud seed. Amer. Nurseryman. 69 (11): 3. 1939.

BLACK LOCUST. *Robinia pseudoacacia.* (Plate V)

The seed of black locust may have a period of dormancy caused by the impermeability of the seed coat to water, but this

characteristic varies. Seeds from different localities or even from different trees require treatments of different intensities. In Oklahoma, some fresh seeds absorb water freely and consequently do not require any treatment whatsoever.

Treatments effective on seeds of black locust are those involving mechanical scarification or soaking in sulphuric acid or hot water. The only way to determine the exact length of treatment is to try several treatments varying in length from 10 to 60 minutes (for Oklahoma seed) on small samples of seed. The average acid treatment of black locust seeds produced in Oklahoma is probably of 20 or 30 minutes duration.

Acid treated seed must be well washed in running water, after which it can be either planted or dried and stored. Treated and dried seed maintains its ability to germinate for at least one year. If dry, the seed should be soaked in water for 8 to 24 hours before being sown. When able to absorb water, black locust seed will germinate in two or three days after it is planted.

Selected References:

Burton, C. L. Variation in characteristics of black locust seeds from two regions. Jour. of Forestry 30: 29-33. 1932.

Chapman, A. G. Scarification of black locust seed to increase and hasten germination. Jour. Forestry. 34 (1): 66-74. 1936.

Hurst, W. M., Humphries, W. R., and McKee, R. Barrel and disk seed scarifiers. U. S. Dept. Agr. Cir. 345, 24 pp. 1935.

Mattoon, W. R. Growing black locust trees. U. S. Dept. Agr. Farmers' Bul. 1628, 14 pp. 1930.

Meginnis, H. G. Sulphuric acid treatment to increase germination of black locust seed. U. S. Dept. Agr. Cir. 453, 33 pp. November 1937.

Wilson, J. K. Scarification and germination of black locust seeds. Jour. of Forestry 35: 241-246. 1937.

HONEY LOCUST. *Gleditsia triacanthos.* (Plate V)

The seed of honey locust has an extremely hard seed coat completely impermeable to water, much more so than the seed of black locust. Any of the three standard methods of modifying the seed coat of this type are effective in permitting the seed to absorb water. If sulphuric acid is used the treatment should last at least two hours. A test on several small samples of seed, for the purpose of determining the proper length of treatment, is very desirable. In commercial work a hot water bath is used more often than a treatment with sulphuric acid.

Selected References:

Fisher, P. L., Briggs, A. H., Elkins, W. A., and Roe, E. I. Propagation of game food and cover plants of the Lake States. Lake States For. Exp. Sta. 1935. (mimeographed.)

KENTUCKY COFFEE TREE. *Gymnocladus dioica.* (Plate V)

Kentucky coffee tree seed belongs to the same type of seeds as those of black locust and honey locust. The cause of the delayed germination is the extremely hard and impermeable seed coat. The seed coat can be modified by any of the three common methods. Before the entire lot of seed is treated, the length of the treatment should be determined by treating a few small samples of seed for various periods of time. Sulphuric acid treatment should probably be not less than two hours in duration and possibly as long as three or four hours.

Selected References:

Fisher, P. L., Briggs, A. H., Elkins, W. A., and Roe, E. I. Propagation of game food and cover plants of the Lake States. Lake States For. Exp. Sta. 1935. (mimeographed.)

WAFER ASH. *Ptelea trifoliata.* (Plate V)

Wafer ash seed having a dormant embryo requires stratification of three months.

Selected References:

Schroeder, E. M. Germination of fruits of Ptelea species. Boyce Thompson Inst. Contrib. 8: 355-359. 1937.

TREE OF HEAVEN. *Ailanthus altissima.* (Plate V)

Freshly gathered Tree of Heaven seed is dormant and needs to be stratified for four months at an average temperature of 41° F.

HOLLY. *Ilex* spp. (Plates V and VI)

American holly *(Ilex opaca)*—The American holly represents one of those rare cases where the inability of the seed to germinate is due to the fact that at the time of seed ripening the embryo is not fully developed. Nothing practical can be done to speed up the development of the embryo. At present, it takes at least two, and more often, three years before the seed can be forced to germinate. The rudimentary embryo is probably only one of several causes of such an abnormally long period of germination.

The common procedure of handling holly seed is to plant it outdoors soon after collection. The first seedlings can be expected to appear during the second spring after planting.

They usually are few. The largest bulk of seed will germinate during the third, and a few seed during the fourth spring after planting.

Deciduous holly *(Ilex decidua)*—The seed of this species is often referred to as a "two-year seed" because it germinates during the second spring after the seed was harvested. The seed may either be planted outdoors soon after it is gathered, or stratified over winter at a temperature of 33° to 45° F. In either case no germination during the first spring should be expected. However, during the second spring the seed germinates very freely.

Selected References:

Crocker, Wm. Harvesting, storage and stratification of seeds in relation to nursery practice. Boyce Thompson Inst. Prof. Paper No. 15. 1930.

Ives, S. A. Maturation and germination of seeds of **Ilex opaca.** Bot. Gaz. 76: 60-77. 1923.

MAPLES. *Acer* spp. (Plate VI)

Sugar maple *(A. saccharum)* seeds should not be allowed to dry. Stratification at 33° F. for 30 to 40 days is needed before planting. Stratification longer than 40 days should be avoided because after-ripened seed germinates freely at a temperature close to freezing.

Norway maple *(A. platanoides)* seed should be handled in the same manner as that of sugar maple. The seed germinates best at 41° F.

Soft or silver maple *(A. saccharinum)* seed ripens in the spring and should be planted as soon as collected. Storing dry seed for any length of time is risky, because it loses viability when moisture content of the seed is reduced to approximately 30 percent. If planting must be delayed, store the seed in a moist place.

Japanese maple *(A. palmatum)*. Stratify seed for three months at 33° to 35° F. This seed can stand dry storage somewhat better than sugar maple—some seeds have germinated after one year of dry storage followed by stratification. When seed has to be planted without being previously stratified, it should be soaked in hot water for several hours before planting.

BOX ELDER *(A. negundo)*. Stratification for 90 days is necessary. Germination is best at fluctuating temperature of 50° to 75° F.

Selected References:

Crocker, Wm. Optimum temperatures for after-ripening of seeds. Assoc. Off. Seed Anal. No. Amer. Proc. 46-48. 1919.

Deuber, C. G. Chemical treatments to shorten the rest period of tree seeds. Science: 73: 320-321. 1931.

Deuber, C. G. and Bowen, P. R. Chemical treatment to shorten the rest period of sugar maple trees. Science: 70: 102. 1929.

Jones, H. A. Physiological study of maple seeds. Bot. Gaz. 69: 127-152. 1920.

SOAPBERRY. *Sapindus drummondii.* (Plate VI)

The chief cause of delayed germination of soapberry seed is the dormancy of the embryo. This is often accompanied also by the inability of the seed to absorb water due to the impermeable character of the seed coat. Consequently while some seeds require only stratification, others may need a treatment preceding stratification, which will modify the seed coat and permit the entrance of water.

The average period of stratification is three months at 35° to 45° F.

Whether a given lot of soapberry seed requires pre-treatment before stratification can be determined by soaking a sample in cold water for a period of five to seven days. If the seeds absorb water and swell in size, no treatment other than stratification is needed. If the seeds remain small and hard, the lot from which they were taken has to be treated before stratification.

Any of the three standard treatments will modify the seed coat. Another treatment which often has the same effect on the seed coat as acid or hot water treatment is stratification at 70° to 85° F. for 6 to 10 weeks. This warm stratification is suggested in preference to the standard methods of treatment of hard-coated seeds because it is more economical, and also because it facilitates removal of the pulp and cleaning of the seed, which otherwise is very difficult and unpleasant. After stratification at 70° to 85° F., the pulp decays and can be washed off without any difficulty. Seed is then given the regular low-temperature stratification.

FLOWERING DOGWOOD. *Cornus florida.*

Dogwood is often self-sterile and seed should therefore be collected from a clump of trees rather than from isolated trees.

The seed when collected is dormant and requires from 100 to 130 days of stratification at temperatures of 32° to 50° F. One must make sure that the seed is fully after-ripened by making a germination test before it is planted, because partly dormant seed of dogwood reverts to the original state of dormancy when exposed to high temperature, and the entire process of after-ripening must be repeated.

Selected References:

Davis, O. H. Germination and early growth of **Corus florida, Sambucus canadensis,** and **Berberis thunbergii.** Bot. Gaz. 84: 225-263. 1927.

CHITTAMWOOD. *Bumelia lanuginosa.* (Plate VI)

Chittamwood seed fails to germinate without pre-treatments because of the dormancy of the embryo and, to some extent, because of the character of the seed coat. The latter is not impermeable to water, yet treatment of seeds with concentrated sulphuric acid is very helpful in increasing germination percentage. Stratification is necessary also. From the relatively meager information now available, it appears that the most effective treatment consists of soaking the seed 20 minutes in concentrated sulphuric acid followed by stratification for four to five months at 35° to 40° F.

ASH. *Fraxinus* spp. (Plates VI and VII)

The seed of white ash *(F. americana)* is dormant when it reaches maturity. After being collected it should be spread in a thin layer and allowed to dry for a few days, after which it can be sacked and stored. Ash seed can withstand more than a year of dry storage without losing its viability to any appreciable extent. However, just as a matter of additional precaution, it is advisable to keep it at a low temperature.

To bring the seed out of dormancy, it is stratified either for 15 to 20 weeks at a temperature of 32° F. or for about 10 weeks at 45° F. Fully after-ripened ash seed will germinate at this temperature. If the seed begins to germinate in storage, the temperature should be lowered to as close to freezing as possible.

Green ash *(F. pennsylvanica, var. lanceolata).* The seed should be handled in the manner recommended for that of white ash, except that the period of stratification does not need to exceed 8 to 10 weeks.

Occasionally a fair percentage of green ash seed is found to have no dormancy and will germinate without cold treatment

immediately after collection. However, even in such cases, stratification will result in better, faster, and more uniform germination.

Selected References:

Heritage, W. Black Ash. Jour. of Forestry 34: 531-533. 1936.

Steinbauer, G. P. Dormancy and germination of **Fraxinus** seeds. Plant Physio. 12: 813-824. 1937.

CATALPA. *Catalpa speciosa.* (Plate VII)

Catalpa seed has no period of natural dormancy, and a good stand of seedlings can be obtained by planting it in the spring of the year without stratification or any other pre-treatment.

Soaking of seed in cold water for two days prior to planting will speed up germination, but will not appreciably increase the final percentage of germination.

Two or three weeks of stratification at 30° to 40° F., although not absolutely essential, will increase the rate of germination and also contribute to the initial vigor of small seedlings.

Selected References:

Lake States For. Exp. Sta. Seed treatment for shelterbelt species. For. Res. Digest 6-7. Aug., 1935.

RUSSIAN OLIVE. *Ealeagnus angustifolia.* (Plate VII)

Russian olive seed requires stratification at 33° to 50° F. for a period of approximately 90 days. Before being stratified the pulp must be removed; this is easily accomplished by macerating the fruit after soaking it in cold water for several days.

Selected References:

Fisher, P. L., Briggs, A. H., Elkins, W. A., and Roe, E. I. Propagation of game food and cover plants of the Lake States. Lake States For. Exp. Sta. 1935. (mimeographed.)

ORNAMENTAL SHRUBS

BARBERRY. *Berberis thunbergii.* (Plate VII)

Germination of barberry seed is helped greatly by temperature alternating between high and low. Such alternating temperature is common in Oklahoma during the months of March and April. It is well, therefore, to have the seed planted outdoors around March 15.

A short period of stratification (two to three weeks) at a low temperature before planting is desirable. A good stand of seedlings can also be obtained from untreated seed planted in the fall.

Selected References:

Davis, O. H. Germination and early growth of **Cornus florida, Sambucus canadensis,** and **Berberis thunbergii.** Bot. Gaz. 84: 225-263. 1927.

BIRD-OF-PARADISE. *Poinciana gilliesi.* (Plate VII)

Bird-of-paradise seed requires no treatment for germination. However, untreated seed germinates slowly and rather irregularly. Stratification at 40° to 45° F. for approximately two weeks speeds up germination markedly.

BITTERSWEET. *Celastrus scandens.*

Dormancy in seed of bittersweet is due to both dormancy of the embryo and mechanical restraint exerted by the seed coat.

In commercial practice the seed is stratified throughout the winter and planted in the spring. In propagation on a small scale, removal of the seed coat preceding stratification might be suggested as a means of improving and speeding up germination.

Bittersweet is propagated by layers and root cuttings more often than by seed.

Selected References:

Hart, H. T. Delayed germination in seeds of **Peltandra virginica** and **Celastrus scandens.** Wash. Univ., Puget Sound Biol. Sta. Pubs. No. 6: 255-261. 1928.

CHERRY LAUREL. *Prunus laurocerasus.* (Plate VII)

Cherry laurel seed can be planted as soon as ripe and can be expected to produce a good stand of seedlings without any pre-treatment or stratification. If stored over winter it can be kept either with or without pulp. However, the pulp must be removed before the seed is planted.

DESERT WILLOW. *Chilopsis linearis.* (Plate VIII)

The seed of desert willow has no period of dormancy and can be sown at any time after it matures. The seed ripens from the late summer to the late fall.

SPINDLETREE. *Euonymus* spp. (Plate VIII)

Dormancy of the embryo makes stratification of seed essential for germiantion. Different species of *Euonymus* require different periods of stratification. The average period for seed of the species grown in Oklahoma is approximately seven to eight weeks. Extension of the stratification period beyond the requirement should be avoided; after-ripened seed germinates freely at a low temperature. The pulp must be removed before the seed is stratified.

Commercially, ornamental varieties of *Euonymus* are propagated almost exclusively by hardwood and softwood cuttings. Some varieties root naturally when branches touch the soil.

SHRUB-ALTHEA. *Hibiscus syriacus.*

Dormancy of shrub-althea seed is broken by stratification at 40° to 45° F. for approximately three to four weeks. Commercially, shrub-althea is propagated almost exclusively by cuttings. The varieties do not come true from seed and the latter cannot be relied upon to produce plants with flowers of the desired color.

HEAVENLY BAMBOO. *Nandina domestica.* (Plant VIII)

At the time the seed of this plant is collected (November to January), it has an imperfectly developed embryo. No practical way is known to hasten the development of the embryo and thus secure an early germination.

No matter when Nandina seeds are planted, they germinate in the late fall or early winter, from October to December inclusive. Germination in other seasons is exceptional. Because of this peculiar behavior, the seed can be planted soon after collection or at any time thereafter until, and including, July.

In commercial work the seed is usually planted in February or March in flats or pots which are kept outdoors through the following spring and summer and brought indoors in September or late August. When the seedlings have formed two or three true leaves, they are potted, kept on the bench till spring, and then lined out in the nursery.

PRIVET. *Ligustrum* spp. (Plate VIII)

Privet seed is commonly stratified before being planted. Fall planting with good protection of seeds should also give good germination.

The exact stratification requirements vary with the species. To be on the safe side it is better to give the seed as long a period of stratification as possible, starting it as soon as the seed is collected and cleaned.

Privet cuttings root very easily and this method of propagation is preferred by many professional growers.

FLOWERING QUINCE. *Chaenomeles lagenaria.* (Plate VIII)

The seed of flowering quince must be removed from the fruit, dried, and stored dry (preferaby at low temperature) until February. Removal of seeds is much easier if the fruit is not allowed to dry too much and harden. The seed must be stratified in February so that by the middle of April it will be ready to be planted. Two months is sufficient for after-ripening. Early stratification should be avoided, because the after-ripened seed will germinate even at a low temperature.

Flowering quince is often propagated by root and hardwood stem cuttings.

ROSES. *Rosa* spp. (Plate VIII)

The seed of all roses has a period of dormancy and requires stratification. This period varies with species. The following stratification schedule is suggested for roses found in Oklahoma, which can be propagated by seed:

	Stratification	
	Temperature (F.)	Period (Weeks)
Rosa multiflora	32°	9-10 (occasionally longer)
Rosa canina	41°	38-40
Rosa hugonis	41°	12-13 (or longer)
Rosa rugosa	41°	12 (or longer)

The most favorable stratification temperature for most rose seeds is 41° F., with the effective range extending from 32° to 50° F. Wide fluctuations in temperature during stratification should be avoided.

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SMOOTH SUMAC. *Rhus glabra.*

The best results in germinating sumac seed can be obtained from seed treated with concentrated sulphuric acid for a period

of 20 minutes and then stored dry at 50° F. for one month. Acid treatment alone improves germination considerably, but not to the extent resulting from its combination with cold dry storage.

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SALT CEDAR. *Tamarix* spp.

Seed of tamarix, having no period of dormancy, can be planted as soon as it ripens. Tamarix, in commercial practice, is more commonly propagated by cuttings, which take root rather easily.

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